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THE

AMERICAN NATURALIST.

Vol. VI.—JUNE, 1872.—No. 6.

STUDENTS' MICROSCOPES.*

BY R. H. WARD, M. D.

THOSE who use the microscope as an elegant and costly luxury will, of course, be guided in so doing by their general ideas of taste, economy, etc.; the few who use the instrument as medical experts, or original investigators in science, will, at the same time, by years of practice, grow into the use and the possession of an instrument suited to their wants; but a larger class are those who use the instrument as an incidental though frequent aid in their daily work in various sciences or professions, who reasonably desire the simplest instruments consistent with real usefulness, and who, however eminent in other specialties, are often unfamiliar with the styles and prices of the various makers, and at a loss to know what available resources would best supply their wants. The following tables are designed to be of use to buyers of microscopes, of the latter class, and to persons who desire information in a concise and convenient form, in regard to the progress thus far made in this department of microscopy. While the styles and prices will be subject to endless variation, the statements made will be sufficiently accurate to form a basis for selection and correspondence for a considerable time.

For the convenience of persons who desire to compare our styles with those of European makers, the table of American Students' Microscopes has been rearranged so as to correspond in form with Dr. J. F. Payne's recently published table of European instru-

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*From a paper on Medical Microscopes, read at the Medical Society of the State of New York, Feb. 7, 1872.

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ments.* Only standard and available styles are given, by reliable American makers, and no such makers have been intentionally omitted. The selection of instruments and apparatus of the different makers is entirely the responsibility of the writer, and not of the makers. He has selected such sets, at the makers' prices, as he has been accustomed to recommend to students and others for the general purposes of students' microscopes.

The table of Objectives is designed to be complete in regard to American lenses, and to present for comparison, and for the convenience of those who desire a variety of lenses by different makers, such European items as could be obtained at the time of writing. It is believed that the table will be interesting to others than buyers, as showing the prevailing powers, prices, angular apertures etc., in different parts of the world. Notwithstanding the general impression that the prices of American objectives are unreasonably high, it will be seen that they compare favorably with those of the most celebrated English makers. Most opticians prepare very cheaply mounted objectives of small angle, and usually second quality, which answer a good purpose where economy is imperative and difficult work is not required. Such lenses are not usually priced and sold separately by the American makers, and are therefore not included in their columns in the table of objectives.† They can be obtained, however, at prices proportioned to their angles and quality. The prices and angular apertures given in the table are generally, though not in every case, official and up to date; but a reasonable allowance must be made for practical variation from the standard angles and powers. There is understood to be a screw-collar adjustment for all objectives of over 50° angular aperture, unless otherwise stated, though, from want of sufficiently distinct description by their makers, this rule cannot be applied to some of the English lenses of medium power and small angle. To persons without great experience in microscopy, the best "test" of an objective is the respectability of its maker.

The Binocular Microscope, though not especially applicable to medical microscopy, is of such general usefulness that it should be preferred in all cases where its price is not a positive objection. Binoculars are furnished, when ordered, even by those makers who do not manufacture them.

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*Quart. Jour. Mic. Sci., Jan. 1872.

†This remark would also apply to a few of the English opticians.

TABLE OF OBJECTIVES, THEIR MAKERS AND PRICES.

Nominal focus in inches.	Angular aperture in degrees.	Grunow.[a] Price in dollars. a.	Miller. Price in dollars. a.	Queen. Price in dollars. a.	Spencer. Price in dollars. a.	Tolles.[k] Price in dollars. a.	Wales.[l] Price in dollars. a.	Zentmayer. Pr. in dollars. a.	Baker. Price in pounds and s. b.	Beck. Price in pounds and s. c.	Browning. Pr. in pounds and shillings. d.	Collins. Price in pounds and shillings. e.	Crouch. Price in pounds and s. f.	Dancer. Price in pounds and s. g.	Horne & Thornthwaite. Pr. in pounds and s. h.	How. Price i pounds and s. i.	Murray & Heath. Price in pounds and shillings. j.	Pillischer. Pr. in pounds and s. k.	Powell and Lealand.[q] Pr. in pounds and s. l.	Ross. Price in pounds and s. m.	Steward. Price in pounds and shillings. n.	Swift. Price in pounds and s. o.	Wheeler. Price in pounds and shillings. p.	Hartnack.[s] Pr. in francs. q.
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TABLE OF OBJECTIVES, THEIR MAKERS AND PRICES.

in dollars. a.	Tolles.[k] Price in dollars. a.	Wales.[l] Price in dollars. a.	Zentmayer. Pr. in dollars. a.	Baker. Price in pounds and s. b.	Beck. Price in pounds and s. c.	Browning. Pr. in pounds and shillings. d.	Collins. Price in pounds and shillings. e.	Crouch. Price in pounds and s. f.	Dancer. Price in pounds and s. g.	Horne & Thornthwaite. Pr. in pounds and s. h.	How. Price i pounds and s. i.	Murray & Heath. Price in pounds and shillings. j.	Pillischer. Pr. in pounds and s. k.	Powell and Lealand.[q] Pr. in pounds and s. l.	Ross. Price in pounds and s. m.	Steward. Price in pounds and shillings. n.	Swift. Price in pounds and s. o.	Wheeler. Price in pounds and shillings. p.	Hartnack.[s] Pr. in francs. q.	Gundlach. Price in thalers. r.	Merz. Price in thalers. s.	Wasserlein. Pr. in thalers. t.	Zeiss. Price in thalers. u.
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a. See Table of Students' Microscopes.
b. C. Baker, 243 and 244 High Holborn, London, England.
c. R. & J. Beck, 31 Cornhill, E. C., " "
d. Jno. Browning, 63 Strand, W. C., " "
e. Chas. Collins, 157c, Great Portland street, Portland Place, W., London, Eng.
f. Henry Crouch, 51 London Wall, E. C., London, Eng.
g. J. B. Dancer, 43 Cross street, Manchester, England.
h. Horne & Thornthwaite, 122 and 123 Newgate street, E. C., London, England.
i. James How, 2 Foster lane, " "
j. Murray & Heath, 69 Jermyn street, S. W., " "
k. M. Pillischer, 88 New Bond street, W., " "
l. Powell & Lealand, 170 Euston Road. " "
m. Thomas Ross, 7 Wigmore street, Cavendish square, W., " "
n. J. H. Steward, 406 Strand, W. C., " "
o. James Swift, 43 University street, Tottenham Court Road, W.C., " "
p. Edmund Wheeler, 48 Tollington Road, Holloway, N., London, "
q. E. Hartnack & Co., 21 Place Dauphine, Paris, France.
r. E. Gundlach, Optical Institute, Charlottenberg, near Berlin, Prussia, Germany.
s. G. & S. Merz, Optical Institute, Munich, Bavaria, Germany.
t. R. Wasserlein, 27 Schutzen street, Berlin, Prussia, "
u. Carl Zeiss, Jena, Germany.

a. Mounts, to special order, objectives as high as 1-10 inch, to work well on any binocular stand.

b. Immersion.
c. Non-adjustable.
d. Changeable, by sliding tube, to 3 inches.
e. Adjustable by front lens.
f. Dry or Immersion.
g. Specially recommended as an achromatic conde
h. Changeable, by reversing, to 2½ inches.
i. Has a front to give 1 inch of 25°.
j. Specially arranged for opaque objects, $28.
k. All of 1-5 or higher, either dry or immersion. Bo with extra front, at extra price.
l. Higher powers to order.
m. Specially for binocular.
n. Divides to give 3 inches.
o. Divides to give 2 inches.
p. Immersion arrangement, £2, 2s. extra.
q. Improved arrangement for thick covering-glass,
r. Extra front, for dry 1-8, £2 extra.
s. All of 1-12 (No. 9) and higher, immersion and adj
u. Extra front for immersion, £2 extra.
v. Extra front for immersion, £2, 10s. extra.
x. By special contract.

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ross street, Manchester, England.
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ter lane, “ “
9 Jermyn street, S. W., “ “
ew Bond street, W., “ “
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k. All of 1-5 or higher, either dry or immersion. Both ways with same lens, or with extra front, at extra price.
l. Higher powers to order.
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SYNOPSIS OF STUDENTS' MICROSCOPES.

MODEL.

Must have joint to incline at various angles from horizontal to perpendicular.

Curved Bar. — "Jackson" (but not prolonged beneath stage); steadiest form for equal weights.

Transverse Bar. — Most convenient in some respects.

WEIGHT.

Four to ten pounds. — A question of convenience *vs* firmness.

HEIGHT. (12 to 16 inches.)

Tall. — Much room below stage. Standard length of tube gives usual powers. Looks well, and is most convenient when inclined.

Short. — Easiest for vertical use. Short tube works lenses at too low power. Should be lengthened by draw-tube when inclined.

DIAMETER OF TUBE. (1 to 1 3-8 in.)

Small. — Looks best and is steadiest on small instruments.

Large. — Gives wider field with low power oculars.

MATERIAL.

All Brass. — Looks best.

Iron Base. — Saves expense. Wears well unless broken by falling.

COARSE ADJUSTMENT.

Rack and Pinion. — Easiest; preferable but costly.

Friction Pinion. — Said to be very delicate.

Chain Movement. — Fine motion. Easily repaired if necessary.

Sliding Tube, by hand. — Saves expense. Most delicate, but awkward. Wants expert hands, and often two of them.

FINE ADJUSTMENT. Essential.

Screw and lever moving nose-piece. —Best. Costly.

Screw and lever moving compound body. — Good for moderate powers.

Screw moving compound body. — Less delicate.

Screw against shoulder, moving nose-piece. — Less delicate.

Screw on nose-piece. — Little used.

Screw moving stage. — Cheapest in use in this country. Bad in theory and history; but quite satisfactory in use, as made at present.

Bar moving pinion of rack. — Not in this country. Good for low powers. May be added to instruments having no other fine adjustment.

STAGE.

Mechanical. — Not required.

Lever. — Plausible, but not successful.

Magnetic. — Plausible, but not successful. (Insecure.)

Hand movement. (In two rectangular directions.) — Best substitute for mechanical, for high powers, and with Maltwood Finder.

Glass, concentric. — Best for Binocular.

Glass, sliding by hand. — Cannot be too highly commended for ordinary medical use.

Brass.—Sliding by hand (cloth-lined, or otherwise). A good and cheap substitute.

Plain. — Saves expense. Should have removable spring clips. Could have glass or brass sliding-stage added.

MIRROR.

Must have lateral, vertical and two rotary movements.

Lateral movement by cranked arm: not common in students' microscopes. Lateral movement by mirror swinging partly around the bar which carries it. Lateral movement by hinge joint at top of bar which carries mirror: obliquity entirely independent of distance of mirror from object.

Concave. — Indispensable. Should be nearly two inches wide.

Plane. — Very desirable and costs little. May be smaller.

DIAPHRAGM.

Fitting should be removable, for oblique light.

Disç with apertures.— Essential. Should be closed between diaphragm and stage to prevent accidental oblique light.

" *Graduating*" or "*Iris.*"—Incomparably best, but unnecessarily expensive.

OCULARS (eye-pieces).

Negative (Huyghens') always meant, unless otherwise stated. Quality (and performance) varies greatly, though seldom suspected.

Two-inch. — (The A or No. 1 of most makers.) X* 5. Best for general use. Should always be negative.

One-inch. — (Often named B or C, or No. 2 or 3.) X 10. Use for Micrometry, occasionally for observations, and generally as achromatic condenser. If willing to add $5.00 or $10.00, substitute Kellner's orthoscopic, by European or American makers (superb field), or Tolles' orthoscopic, by Boston Optical Works (field narrower, but peculiarly clear).

OBJECTIVES. (If extravagant anywhere, put it here.)

All above 50° angular aperture, should have adjustment for cover glass.

All above about 75° must have the same.

Screw collar. — Best.

Screw movement of outer tube.—Good for cheap lenses of small angles.

Sliding movement of outer tube, with oblique slot.—Good for cheap lenses of small angles.

One-inch. — X 10 (with lowest ocular, X about 50). Should be about 25° angular aperture.

One-fourth or one-fifth inch. —X 40 or 50 (with low ocular, X about 200 or 250). May be 75° to 85°.

One-sixth to one-eighth inch. — X 60 to 80. (With low ocular, X about 300 to 400.) Should be 120° to 140°. Best added after a few years' experience with the others.

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* Magnifies, diameters.

MAGNIFYING POWERS.

Quality more than quantity.

Theoretical. — One inch X 10. Oculars and objectives as above, X 50, 100, 200, 400, 800.

Practical. — Should approximate to this.

ACCESSORIES.

Essential, and should be furnished free.

A few glass slides and covers; stage-plates with ledge; pipettes; pliers; and needles mounted in handles.

Desirable, for medical and general use.

Compressorium, or *animalcule cage.*
Curved scissors (sideways).
Camera lucida, for drawing and micrometry.*
Stage micrometer.
Graduated Draw-tube.
Cylindrical fitting, below stage, to use ocular for achromatic condenser.
Reagents. (In twelve one or two ounce vials.)
Turn table, and mounting materials.

Desirable, more for general than medical use.

Condensing lens, on separate stand, for opaque objects, and for parallel light, etc.; or *condensing lens* to limb or stage of instrument, for opaque objects; or *mirror on curved arm*, to swing above stage, for opaque objects; or *mirror removable* to stage or separate stand for opaque objects.

Spotted lens, or glass paraboloid, for translucent objects.
Stage forceps.
Maltwood finder.

PRICE.

Including walnut or mahogany case, $50 to $100. Varies with quantity and quality of work and reputation of maker.

Less, at present, unsatisfactory.
More, unnecessary.
About double, by substituting binocular stand.

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* For occasional measurements the camera is entirely satisfactory. Where large numbers of measurements are to be made, this method is not sufficiently rapid and convenient. Dr. White's micrometer, a semicircle of thin glass, graduated at the straight edge, and lying upon the diaphragm in focus of the eye lens, is most used by the writer for this purpose. With low powers the object is easily brought up obliquely to the required position; for high powers the Jackson adjusting screw must be used, unless the stand have a mechanical stage. The simplest ocular micrometer, and best for general students' use, is a circular disc cut, to fit, from the centre of a rather thin stage-micrometer graduated to hundredths or to two-hundredths of an inch, and lying, only when used, upon the diaphragm in the ocular like Dr. White's form. This rather thick circle is more durable, more easily obtained and handled, and capable of giving unexpectedly good results. It should cost $2 or $3.

Name and address of maker.	Name of instrument.	Model.	Height (in inches) with high powers.	Weight (in lbs.)	Inside diameter of tube (in inches).	Material (brass except as stated).	Coarse adjustment.
Boston Optical Works.* Chas. Stodder, Agent, 66 Milk St., Boston.	Tolles' Students' Microscope.	Jackson.†	$15\frac{1}{2}$	6	.96	Iron base and arm.	Sliding tube with steel spring.
Boston Optical Works.* Chas. Stodder, Agent, 66 Milk St., Boston.	Tolles' Students' Microscope.	Jackson.†	$15\frac{1}{2}$	6	.96	Iron base and arm, $10.00 extra for all brass.	Rack and pinion.
J. Grunow, 410 Fourth Av., N. Y.	Students' Microscope (horse-shoe base).	Transverse bar.	12	5	$\frac{31}{32}$	Brass.	Sliding tube.
J. Grunow, 410 Fourth Av., N. Y.	Students' Microscope (horse-shoe base).	Transverse bar.	12	5	$\frac{31}{32}$	Brass.	Sliding tube.
T. H. McAllister, 49 Nassau St., N. Y.	Students' Microscope.	Transverse bar.	12	$4\frac{1}{2}$	1	Iron base.	Chain movement.
T. H. McAllister, 49 Nassau St., N. Y.	Professional Microscope.	Transverse bar.	15	7	$1\frac{5}{16}$	Iron base.	Chain movement.
Wm. Y. McAllister, 728 Chestnut St., Philad.	(No. 5374.)	Transverse bar.	13	$4\frac{2}{3}$	$1\frac{1}{16}$	Iron base.	Sliding tube.
Wm. Y. McAllister, 728 Chestnut St., Philad.	(No. 5374.)	Transverse bar.	13	$4\frac{2}{3}$	$1\frac{1}{16}$	Iron base.	Sliding tube.
Miller Bros., 1223 Broadway, N. Y.	Students' Microscope.	Jackson.	16	5	$1\frac{1}{4}$	Iron base and arm.	Sliding tube, in cloth.
Miller Bros., 1223 Broadway, N. Y.	Educational Microscope.	Transverse bar.	15	4	$1\frac{3}{16}$	Brass.	Rack and pinion.

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* R. B. Tolles, superintendent.

† Arm expands to fill whole space between uprights, and gives, with conical steel pin, a very simple Trunnion joint.

Fine adjustment.	Stage.	Mirror.	Oculars.	Objectives.	Range of magnifying powers.	Accessory apparatus.	Price with case (in dollars).	Price of cheapest binocular stand only (in dollars).
Screw to stage.	Plain, with spring clips.	Concave, $1\frac{7}{8}$ in., with side movement.	$1\frac{1}{2}$ in.	1 in. & $\frac{1}{4}$ in.	75 to 300.	Mirror to separate stand for opaque illumination.	50.	80., *extra* for binocular eye-piece.
Screw with lever to nose-piece.	Plain, with fitting for accessories.	Plane and concave, $1\frac{7}{8}$ in., with side movement.	$1\frac{1}{2}$ in.	1 in. & $\frac{1}{4}$ in.	75 to 450.	Mirror to separate stand for opaque ill., draw-tube & camera lucida.	100.	80., *extra* for binocular eye-piece.
Screw to compound body.	Plain, with spring clips ‡.	Plane and concave, $1\frac{5}{8}$ in., with hinge movement.	Two.	$\frac{2}{3}$ in. 25° and $\frac{1}{5}$ in. 90°	70 to 500.	None.	85.	None.§
Screw to compound body.	Plain, with spring clips‡.	Plane and concave, $1\frac{5}{8}$ in., with hinge movement.	Two.	$\frac{2}{3}$ in. 25° and $\frac{1}{5}$ in. 90°	70 to 500.	Camera lucida, stage micrometer & compressorium.	100.	None.§
Screw to stage.	Plain, with spring clips.	Plane and concave, with hinge movement.	B	1 in. & $\frac{1}{4}$ in. (French.)	50 to 400.	Draw tube and stage forceps.	50.	None, at present.
Screw with lever to nose-piece.	Glass, sliding by hand.	Plane and concave, with hinge movement.	A & B	1 in., $\frac{1}{2}$ in. & $\frac{1}{4}$ in.	50 to 600.	Draw tube and stage forceps.	100.	None, at present.
Screw with lever to compound body.	Glass, sliding by hand.	Concave, with hinge movement.	Two.	One set of Fr., dividing.	50 to 350.	Condensing lens on stand.	50.	None.
Screw with lever to compound body.	Glass, sliding by hand.	Concave, with hinge movement.	Two.	$\frac{8}{10}$ in. 32°, & $\frac{1}{5}$ in. 120°. (Zentmayer.)	50 to 430.	Condensing lens on stand, camera lucida stage micrometer, & animalcule cage.	100.	None.
Screw to stage.	Plain, with spring clips.	Concave, with hinge movement.	A & B	1 in. 16° and $\frac{1}{4}$ in. 75°	37 to 310.	Mirror to stage for opaque ill.	60.	100.
Screw with lever to nose-piece.	Plain, with spring clips.	Concave, $1\frac{5}{8}$ in., with side movement.	A & B	1 in. 16° and $\frac{1}{4}$ in. 75°	37 to 310.	Stage plates & condensing lens on stand.	80.	100.

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‡ Diaphragm, sunk into upper surface of stage, so as to be close to the object slide.
Makes optical parts, to work with Zentmayer's binocular hospital-stand.

Name and address of maker.	Name of instrument.	Model.	Height (in inches) with high powers.	Weight (in lbs.)	Inside diameter of tube (in inches).	Material (brass except as stated).	Coarse adjus ment.
B. Pike's Son, 518 Broadway, N. Y.	Students' Microscope.	Jackson.	15	5	$1\frac{3}{8}$	Iron base and arm.	Rack and pinion.
B. Pike's Son, 518 Broadway, N. Y.	Physicians' Microscope.	Jackson.	15	5	$1\frac{3}{8}$	Iron base.	Chain movement.
Jas. W. Queen & Co., 924 Chestnut St., Phil., and 535 Broadway, N. Y.	Students'‖ Microscope. (No. 1665).	Jackson.	14	5	$1\frac{3}{8}$ (scant).	Iron base and arm.	Sliding tube.
Jas. W. Queen & Co., 924 Chestnut St., Phil., and 535 Broadway, N. Y.	Students'‖ Microscope. (No. 1665).	Jackson.	14	5	$1\frac{3}{8}$ (scant).	Iron base and arm.	Sliding tube.
Chas. A. Spencer & Sons, Canastota, N. Y.	Students' Microscope.	Jackson.	15	6	1.18	Iron base and arm.	Sliding tube, in velvet.
Chas. A. Spencer & Sons, Canastota, N. Y.	Students' Microscope.	Jackson.	15	6	1.18	Iron base and arm.	Rack and pinion.
Chas. A. Spencer & Sons, Canastota, N. Y.	Standard Microscope.	Jackson.	17	11	1.18	Iron base and arm.	Rack and pinion.
Wm. Wales,¶ Fort Lee, N. J.							
J. Zentmayer, 147 South 4th St., Philadelphia.	Students' Microscope. (Roundbase.)	Jackson.	15	$5\frac{1}{2}$	$1\frac{3}{8}$	Brass.	Sliding tube.
J. Zentmayer, 147 South 4th St., Philadelphia.	Students' Microscope. (Roundbase.)	Jackson.	15	$5\frac{1}{2}$	$1\frac{3}{8}$	Brass.	Sliding tube.

‖ Accessories of Beck's "popular" stand fit this.

¶ Makes optical parts only, to stands by any maker.

Continued.

Fine adjustment.	Stage.	Mirror.	Oculars.	Objectives.	Range of magnifying powers.	Accessory apparatus.	Price with case (in dollars).	Price of cheapest binocular stand only (in dollars).
Screw with lever to stage.	Glass, sliding by hand.	Plane and concave.	A & B	1 in. & $\frac{1}{8}$ in. (Gundlach).	50 to 600.	Condensing lens on stand.	75.	125.
Screw with lever to compound body.	Glass, sliding by hand.	Plane and concave.	A & B	1 in. & $\frac{1}{8}$ in. (Gundlach).	50 to 960.	Condensing lens on stand, & draw tube.	100.	125.
Screw with lever to nose-piece.	Glass, sliding by hand, with fitting for accessories.	Plane and concave, with hinge movement.	A.	$\frac{1}{5}$ in. (dividing).	100 to 300.	Stage micrometer and condensing lens on stand.	60.	None.
Screw with lever to nose-piece.	Glass, sliding by hand, with fitting for accessories.	Plane and concave, with hinge movement.	A & B	1 in. 18° and $\frac{1}{5}$ in. 80°	50 to 500.	Stage micrometer, condensing lens on stand, camera lucida & compressorium.	100.	None.
Screw to stage.	Plain, with spring clips.	Plane and concave, $1\frac{3}{4}$ in., with hinge movement.	B	1 in. 20° and $\frac{1}{4}$ in. 60° adj.	85 to 325.	Mirror on curved arm to swing above stage for opaque ill.	60.	None.
Screw with lever to nose-piece.	Plain, with spring clips.	Plane and concave, $1\frac{3}{4}$ in., with hinge movement.	B	1 in. 20° and $\frac{1}{4}$ in. 60° adj.	85 to 325.	Mirror on curved arm as above, camera lucida and animalcule cage.	100.	None.
Screw with lever to nose-piece.	Plain, with spring clips.	Plane and concave, 2 in., with hinge movement.	B	$\frac{1}{4}$ in. 60° adj.	325.	Mirror on curved arm as above.	100.	None.
Screw to stage.	Plain, with spring clips, and tube for accessories.	Plane and concave, $1\frac{7}{8}$ in., with hinge movement.	A & B	$\frac{8}{10}$ in. 22° and $\frac{1}{5}$ in. 85°	50 to 430.	Condensing lens to limb.	75.	135.
Screw to stage.	Plain, with spring clips, and tube for accessories.	Plane and concave, $1\frac{7}{8}$ in., with hinge movement.	A & B	$\frac{8}{10}$ in. 22° and $\frac{1}{5}$ in. 85°	50 to 430.	Condensing lens to limb, camera lucida, stage micrometer, & compressorium.	90.	135.